

Case Study

# Farm Level Technical Efficiency of Paddy Production in Andhra Pradesh: An Empirical Evidence from the Cost of Cultivation Survey Data

K.S.R. Paul,<sup>1\*</sup> G.P. Sunandini<sup>2</sup>, Shakuntala Irugu<sup>3</sup> and K. Suhasini<sup>4</sup>

<sup>1</sup>Senior scientist, Cost of Cultivation Scheme, Agricultural College, Bapatla, Professor Jayashankar Telangana State Agricultural University, Andhra Pradesh, India

<sup>2</sup>Principal Scientist & Field Officer, Department of Agricultural Economics, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India

<sup>3</sup>Scientist, Cost of Cultivation Scheme, Regional Agricultural Research Station, Palem, Professor Jayashankar Telangana State Agricultural University, Nagarkurnool, Telangana, India

<sup>4</sup>Professor, Univ. Head & Associate Dean, Department of Agricultural Economics, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India

\*Corresponding author: [ksolmonrajupaul@gmail.com](mailto:ksolmonrajupaul@gmail.com) (ORCID ID: 0000-0001-7300-1213)

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## ABSTRACT

The study calculated technical efficiency, Data Envelopment Analysis technique was employed, one of the non-parametric linear programming techniques to estimate the farm level technical efficiency of paddy production in Andhra Pradesh. This secondary data set contained 541 paddy producing farms/units across Andhra Pradesh state under five agro climatic zones viz North coastal, Godavari, Krishna, Southern and Scarce rainfall zones was studied. The results showed that the overall technical efficiency of the entire sample is 86.8 per cent inferring that about 13 per cent of the potential paddy yield is lost because of technical inefficiency in Andhra Pradesh. The yield gap was found to be 981.10 kg/ha in Godavari zone and a minimum yield gap of 335 kg/ha in North coastal zone with an average yield gap of 663 kg/ha for Andhra Pradesh indicating domestic paddy production could be significantly increased only by improving farmers practices with the current amount of resource they are using. The study suggested that there should be exposure to the improved technologies, frequent trainings and experience sharing mechanisms with efficient resource management practices.

## Highlights

- The marginal farms are found to be more technically efficient because even if limited amount of inputs they apply with personal care using family labour

**Keywords:** Data Envelopment Analysis, paddy production, technical efficiency, non-parametric method

Paddy is the widely consumed staple food for a large part of the world's human population, especially in Asia. Rice is one of the three major crops in the world among maize and wheat. Paddy is grown in an area of 43.79 M ha with a production and productivity of 112.75 M t and 2576 kg ha<sup>-1</sup> respectively in India (Agricultural statistics at a glance 2018). As per USDA report the global production of rice in 2019-20 is 115 Million

metric tonnes after China 146 Million metric tonnes as compared to 2018-19 it was 115.63 in India and 148.5 in China. According to this report (Table 1) it is clear that the production in China and India

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is has declined. (Paddy Outlook, July 2019) when considered the production and productivity over the years there is a lot of fluctuations for the past decade as shown in the Table 2. In Andhra Pradesh, paddy is grown in an area of 2.18 M ha with production of 126.91 M t and productivity of 5722 kg ha<sup>-1</sup> respectively (Agricultural statistics at a glance 2018), (Singh *et al.* 2020).

**Table 1:** Major Rice Producing Countries in the World Production in million metric tons

Country	2018-19	Per cent	2019-20	Per cent
USA	7.12	1.71	6.29	1.51
India	115.63	27.70	115	27.68
Pakistan	7.4	1.77	7.5	1.81
Thailand	20.72	4.96	20.9	5.03
Vietnam	27.71	6.64	28	6.74
Brazil	7.34	1.76	7.34	1.77
European Union	1.98	0.47	2.04	0.49
Indonesia	37.1	8.89	37.4	9.00
Nigeria	4.7	1.13	4.9	1.18
Philippines	11.8	2.83	12.2	2.94
Burma	13.18	3.16	13.3	3.20
China	148.5	35.57	146	35.14
Egypt	2.8	0.67	3.05	0.73
Japan	7.65	1.83	7.7	1.85
South Korea	3.87	0.93	3.88	0.93
Total	417.5	100.00	415.5	100.00

Source: [www.usda.gov](http://www.usda.gov), [pjtssau.edu.in](http://pjtssau.edu.in).

Efficiency in production is a can be increased by using good technology along with better management of resources, available at the farmer s disposal. To increase the productivity the resources/ inputs have to be efficiently used which otherwise leads to inefficiency/ inability to produce maximum

possible output even if the given level of inputs is made available. The present study was taken up with an objective to calculate the farm level technical efficiency and yield gap of paddy production in Andhra Pradesh technical.

## MATERIALS AND METHODS

The required farm level data is obtained from ‘the comprehensive scheme for cost of cultivation of principal crops funded by the Directorate of Economics & Statistics (DES), Ministry of Agriculture, Govt. of India. This secondary data set contained 541 paddy producing farms/units across Andhra Pradesh state under five agro climatic zones viz North coastal, Godavari, Krishna, Southern and Scarce rainfall zones. The study used the latest available data for the year 2016-17 with an objective to calculate the technical efficiency and yield gap. For calculating technical efficiency Data Envelopment Analysis technique was employed.

## TOOLS USED FOR ANALYSIS

### Data Envelopment Analysis (DEA) approach

Efficiency is the key to understand the use of factor inputs for the production of particular product. There are many statistical techniques to calculate the efficiency of a production unit. Data Envelopment Analysis is one of the non-parametric linear programming techniques which creates a frontier with the score ranging between zero and one. The efficient firms are those which produce more output with same levels of inputs or same output with less inputs. This paper has used the

**Table 2:** Season-wise Area, Production and Productivity of Rice in India

Year	Area (In ‘ 000 Ha)			Production (In ‘ 000 Tonne)			Productivity (In Kg./Ha)		
	Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total
2010-2011	38018	4845	42862	80607	15363	95970	2120	3171	2239
2011-2012	40123	3883	44006	92738	12563	105301	2311	3235	2393
2012-2013	38914	3840	42754	92368	12873	105241	2374	3353	2462
2013-2014	39449	4687	44136	91497	15149	106646	2319	3232	2416
2014-2015	39828	4282	44110	91391	14091	105482	2295	3291	2391
2015-2016	39656	3843	43499	91413	12995	104408	2305	3382	2400
2016-2017	39846	4148	43993	96303	13396	109698	2417	3230	2494
2017-2018	39349	4425	43774	97135	15622	112758	2469	3531	2576
2018-2019	39964	4192	44156	102040	14438	116478	2553	3444	2638

Source: Ministry of Agriculture & Farmers Welfare, Govt. of India. (ON2374) & Past Issues.

DEA technique to find out the efficiency of firms in comparison of those farms which have the least input output ratio. The most efficient firm has the score one and the most inefficient firm will have the score zero (Mousavi-Avval *et al.* 2011). The aim is to have optimized output level for the farmers by analyzing the performance data so that the best score is chosen. The inputs taken are family labour hours, casual labour hours, bullock/machine work hours, seeds, manure and fertilizers and the yield is taken as the output.

Each farm is considered as the Decision-making Unit (DMU) and there are  $K$  farmers who are using  $N$  inputs to produce  $M$  outputs. Inputs are indicated by  $x_{jk}$  ( $j = 1, 2, \dots, n$ ) and the outputs are denoted by  $Y_{ik}$  ( $i = 1, 2, \dots, m$ ) for each farmer  $k$  ( $k = 1, 2, \dots, K$ ). The aim is to find the technical efficiency (TE) of the farmers using the method as specified by Coelli (1998), Worthington (1999), Coelli and Battese (1996), Battese, and Coelli (1995) which is represented by the following equation (Singh *et al.* 2019),

$$TE_k = \sum_{i=1}^m u_i y_{ik} / \sum_{j=1}^n v_j x_{jk}$$

where,  $Y_{ik}$  is the amount of the  $i^{\text{th}}$  output produced by the  $k^{\text{th}}$  farmer.  $x_{jk}$  is the quantity of  $j^{\text{th}}$  input used by the  $k^{\text{th}}$  farmer.  $u_i$  and  $v_j$  are the output and input weights respectively. The farmer maximizes the technical efficiency,  $TE_k$ , subject to,

$$TE_k = \sum_{i=1}^m u_i y_{ik} / \sum_{j=1}^n v_j x_{jk} \leq 1$$

Where,  $u_i$  and  $v_j \geq 0$

This equation shows that the weight assigned to inputs and output are positive and the technical efficiency score for a farmer cannot be more than one. The selection of weights is done in such a manner that technical efficiency of the farmer is optimized. To choose optimal weights the linear programming model given below has been taken

Min  $TE_k$

Subject to,

$$\sum_{i=1}^m u_i y_{ik} - y_{jk} + w \geq 0$$

where,  $k = 1, 2, \dots, K$

$$\sum_{j=1}^n x_{jk} - \sum u_j x_{jk} \geq 0$$

and  $u_i$  and  $v_j \geq 0$

The above mentioned model shows Technical Efficiency under constant returns to scale (CRS) with the assumption that if  $w$  is equal to 0 it will lead to Technical Efficiency. If  $w$  is unconstrained then it changes into variable returns to scale (VRS) and pure technical efficiency (PTE) is estimated. Technical Efficiency may be defined as the ratio of sum of the weighted outputs to sum of weighted inputs.

### Yield gap estimation

Once the analysis of technical efficiency is done it is easy to find the level of potential yield of the crop for all the agro climatic zones of the state. In this study the zone wise yield gap for the paddy crop using formula as below has been estimated

Potential Yield = Existing Yield / Technical Efficiency

Yield gap = Potential Yield – Existing yield

## RESULTS AND DISCUSSION

### Estimation of resource use efficiencies

Zone-wise technical efficiencies of paddy are presented in Table 3. Descriptive results of technical efficiency from the table showed that there is a variation in technical efficiency of paddy producers in Andhra Pradesh among the agro-climatic zones with a smallest and largest mean technical efficiency of 0.818 (81.8%) and 0.883 (88.7%) in scarce rainfall zone and Godavari zone, respectively. The overall technical efficiency of the whole sample is 86.8% implying that about 13% of the potential paddy yield is lost due to technical inefficiency in Andhra Pradesh (Singh, 2007), (Meenasulochani *et al.* 2018).

The level of technical efficiency is directly related to the average paddy productivity in the agro climatic zones of Andhra Pradesh. Particularly in Andhra Pradesh the Godavari zone and krishna zone paddy farmers possess high managerial skills compared with other zones. Therefore, raising the proportion of farmers with high technical efficiency would have a great impact on increasing paddy production without incurring additional cost of production but adopting the best management

**Table 3:** Technical efficiency in paddy of Andhra Pradesh

Sl. No.	Zone	North coastal Zone	Godavari Zone	Krishna Zone	Southern Zone	Scarce Rainfall Zone	Andhra Pradesh
1	Technical Efficiency	0.825	0.883	0.874	0.842	0.818	0.868

**Table 4:** Farm-size wise technical efficiency of paddy growers in Andhra Pradesh

Farm size	Marginal (less than 1ha)	Small (1-2 ha)	Medium (2-4 ha)	Semi-medium (4-6 ha)	Large (greater than 6 ha)
Technical efficiency	0.882	0.872	0.861	0.866	0.868

**Table 5:** Average yield gap due to technical inefficiency of paddy growers in Andhra Pradesh in 2016-2017

Sl. No.	Variable	North coastal Zone	Godavari Zone	Krishna Zone	Southern Zone	Scarce Rainfall Zone	Andhra Pradesh
1	Existing Yield (Kg/ha)	2504.71	6683.73	5553.09	4951.82	4553.15	4952.46
2	Technical Efficiency	0.882	0.872	0.861	0.866	0.868	0.882
3	Potential Yield (Kg/ha) (1/2)	2839.81	7664.83	6449.58	5718.04	5245.56	5614.51
4	Yield Gap (Kg/ha) (3-1)	335.10	981.10	896.49	766.22	692.41	662.51

practices in the agro climatic zone. This could be in effect through arranging exposure to the improved technologies, frequent trainings and experience sharing mechanisms also efficient resource management practices (Pradhan, 2018).

### Farm-size wise technical efficiency

The technical efficiency varies according to farm size. Farm-size wise technical efficiency of paddy in Andhra Pradesh is presented in Table 4. The table shows that the marginal farms are found to be slightly more technically efficient than semi-medium and medium farms. This could be because even though they use very less amount of inputs they might apply them with personal care by themselves more efficiently since the usage of family labour is evidently more as the size of the farm decreases to reduce the out of pocket expenditure (Devi and Singh, 2014). However, farm sizes do not have a significant role in harnessing the potential of the paddy farms in Andhra Pradesh. Other measures to increase the technical efficiency are to be taken up across the farm sizes. But the contribution of family labour should be encouraged by medium, semi-medium and large farmers (Bhatt, 2014) (Okello *et al.* 2019).

### Yield gap due to technical inefficiency

The average yield gap between the potential and the actual yield is shown in Table 5. The table indicated that there is a maximum yield gap of 981.10 kg/ha in Godavari zone and a minimum yield gap of 335 kg/ha in North coastal zone with an average yield gap of 663 kg/ha for Andhra Pradesh (Jain *et al.* 2016).

This implies that there is a large yield gap that could be captured by raising the level of technical efficiency of paddy producers in Andhra Pradesh (Naveen and Paramasivam, 2019). This in turn helps the state to be efficient producer and increase the share of paddy production in the country. This will further help in increasing the exports.

### CONCLUSION

The results indicated that the technical efficiency of paddy producers is about 0.87% for Andhra Pradesh but varies from Zone to Zone. The result shows that the average yield gap due to technical efficiency of farmers ranges from 335 kg/ha (North Coastal Zone) to 981 kg/ha (Godavari zone) with a yield gap of 663 kg/ha for the Andhra Pradesh indicating paddy production in the state could be significantly increased by improving management practices of the farmers with the same amount



of resources they are using. Capacity building on usage of appropriate scientific information to capture highest potential resource use efficiency with less cost, innovative methods to reduce the wastage and dissemination of all farm relevant knowledge material should be encouraged to make the technical efficiency more and more.

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